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ABSTRACT

This paper takes issue with the position that children's phoneme acquisition schedule is dictated primarily by auditory perceptual factors and suggests the alternative position that ease of production accounts for age of acquisition. It is felt that perceptual theory cannot adequately explain phonological development, e.g. three-year-olds produce certain sounds which they will not accurately perceive until much later and vice versa. Three psychological scaling tests are described in which adults were asked to designate certain phonemes as harder or easier to produce. These judgments were compared with the phonemes acquired by three-year-olds. A highly significant correlation between the adult ratings and children's phoneme acquisition was found. Featural analysis tended to support the hypothesis, and further confirmation was seen in the patterning of articulatory errors among children. The author stresses that these findings do not negate the importance of perceptual factors, emphasizing that he is trying to explain not the dynamics of phoneme acquisition but rather the schedule which it follows. It is, however, emphasized that there is no compelling evidence for perceptual theory, and certain observations which either militate against perceptual theory or encourage alternative speculation are discussed. (FWB)

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CHILDREN'S RESEARCH CENTER
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CHILDREN'S ACQUISITION OF PHONOLOGY: THE LEARNING OF ACOUSTIC STIMULI?

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Children's Acquisition of Phonology: The Learning of Acoustic Stimuli?

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Some previous papers have suggested that children's phoneme acquisition schedule is dictated primarily by auditory perceptual factors. Olmstead's theory (1966), for example: " . . . predicts learning, measured by correct pronunciation of phones, as a function of ease of perception. The general prediction is that more discriminable phones are learned earlier and the less discriminable ones later."

The problem with perceptual theory is that it does not adequately explain phonological development. For example, three-year-olds produce certain sounds which they will not accurately perceive until much later; conversely, they perceive accurately some phonemes which they will not acquire for several years. So one is compelled to look for viable alternative constructs, and is confronted with the motor-response side of the question. We know something about perceptual ease, but what is the ease of phoneme production? To those who have equated "early" and "late" with "easy" and "difficult" the question may seem absurd, but age of acquisition and ease of production are not identical, and in this paper we asked whether the latter could account for the former.

To get at this matter of motoric ease we designed three psychological scaling tasks in which naive, normal-speaking, native-English adults attempted to introspect and estimate the muscular tensions in their vocal tract during

subvocal speaking. In the first study we wondered whether phonemes which entered children's phonemic systems late in the acquisition schedule would be adjudged more difficult to articulate than earlier-mastered sounds. Such evidence might be interpreted as some kind of loose support for a theory which attempted to explain phoneme acquisition as a function of the muscular ease of articulation. We selected 12 syllable-initial consonant phonemes from Templin's tabulations on acquisition (1957, Appendix IV, Table 2) and assigned them to two lists. One grouping contained five items which were the most commonly correct phonemes of three-year-olds, the other list comprised the five phonemes which were least commonly correct in eight-year-olds. These items preceding a central vowel were paired across lists in all possible combinations and randomized in accordance with pre-established patterns which defeat guessing (Gellermann, 1933). Twenty-two subjects were presented the resulting 25 pairs on paper and instructed to say each pair of sounds silently, pronouncing them just as the examiner had, and to decide which member of each pair was harder to say. "Harder" was defined as requiring slightly more muscular effort or tension in the mouth, tongue or throat than the other member in the pair.

Subjects identified as "harder" and "easier" the five phonemes which comprise the "late" and "early" lists at a level significantly greater than chance ($p < .05$). In this small sample, however, we were not particularly impressed with the order of easiest-to-hardest which resulted compared to the greatest-to-least mastery of these phonemes by Templin's three-year-olds. Of course we knew at the outset that this work did not constitute a rigorous test of the hypothesis, though we did feel that these findings were encouraging enough to undertake a more thoroughgoing investigation of the question.

In a second experiment we used as many phonemes as we could, again limited only by privilege of occurrence and the degree to which phonemes could unambiguously be represented by orthographic characters. As in the previous experiment, each CV stimulus was paired with each other stimulus to form 190 pairs. These pairs were randomly assigned to five lists of 38, within the restriction that no phoneme could immediately succeed itself, with further randomization of the parallel order of each phoneme. Each of the five lists was presented to 11 subjects who received instructions similar to those in Experiment 1.

Data was tabulated by tallying the number of times each phoneme was encircled by the total group of 55 subjects. Statistical analysis showed ranks assigned on the basis of muscular ease to be significantly ($p < .05$) correlated with ranks assigned on the basis of percentage of mastery by three-year-olds[2], although the correlation was a low .490. We decided to postpone featural analyses until we had observed the degree of correlation between rating scale data for these same phonemes and acquisition data.

In our third experiment we followed a previously established format (Smith and Landy, 1965), and asked subjects to estimate the magnitude of effort required to subvocally articulate the 20 phonemes by encircling a number from 1 to 9. The 20 phonemes were randomized into 53 different orders and presented for evaluation to 53 subjects.

Means were derived for each phoneme and the resulting 20 means were ranked for correlational analysis with the ranks assigned on the basis of Templin's acquisition data (1957, Appendix IV, Table 2). The results of this analysis yielded a highly significant ($p < .005$) and higher correlation ($r = +.660$) between adult ratings of muscular ease of articulation and children's acquisition of phonemes.

Featural analysis revealed some interesting parallels between degree of mastery of certain phonetic dimensions by three-year-olds and the estimated muscular ease with which adults articulate these features. Analysis by place of articulation showed that bilabial, alveolar, palatal, and velar points of constriction were in fairly close agreement with some disparity for labio-dental phonemes. Analysis by manner of articulation revealed an interweaving curve with greatest discrepancy occurring with plosive phonemes. Analysis by voicing showed voiceless phonemes, mastered to a higher degree by three-year-olds, also to be considered muscularly easier to articulate by adults. At this point it is impossible to determine whether discrepancies between adult judgments of muscular ease and children's mastery are attributable to limitations in the rating scale method, the use of adults to do the rating, the inability of muscular ease to explain fully the chronology of phoneme acquisition, or other factors.

If muscular ease is in some way a governing factor in children's phonological development, it would seem to reveal its influence in the patterning of their articulatory errors. We wonder if in the case of so-called substitution errors the target phoneme would require greater muscular effort than those phonemes substituted for them. Such a finding would be consistent with a "least effort" notion used to explain certain aspects of phonetic behavior (Wise, 1957,page 151). Certainly it would be puzzling to find that substituted phonemes required greater effort than target phonemes. We examined these ratings for the 10 most common word-initial substitutions (from Snow, 1963) involving phonemes used in this study. As expected, substituted phonemes received significantly lower ease ratings, that is, were rated as muscularly "easier" than the target phonemes ($\underline{t} = 2.546$; $p < .025$). We were tempted,

finally, to compare ease-acquisition correlations with those for acquisition and some measure of phoneme perception. Very little useful data is available on this point. Most perception studies have used subjects older than Templin's three-year-olds, or as in Templin's own study of perception, have employed tests of discrimination rather than identification. We did not want discrimination data because it is shaped by the experimenter as a function of the pairings he chooses; it is, therefore, impossible to rank; and we do not think it is nearly as relevant to phoneme acquisition as identification testing.[3] Therefore, we looked at the correlation between acquisition data and the accuracy of phoneme identification in three-year-olds reported by Koenigsknecht (1970). The lower correlation which resulted ($r = .075$; $p > .05$) tempts one to suggest that motoric ease may well be more important in the acquisition schedule for specific phonemes and consequently more suspicious etiologically in the case of disordered articulation than perceptual ease, although there are no firm grounds for positing causality on the basis of correlational data alone, much less this data derived on three different groups, two of children and one of adults.

The findings of these studies do not negate the importance of perceptual factors in children's acquisition of phonology. In the first place, we were not attempting to explain the dynamics of phoneme acquisition, only the so-called "schedule" it appears to follow. In the second place, such a judgment probably is inappropriate if not impossible on the basis of phoneme production data derived from pictorial elicitation of isolated words. This may suggest a crude picture of children's articulation, but it hardly constitutes a measure of phonology. And as suggested previously, muscular, perceptual, and phonological data must be derived from a common group of very young children if their interrelationships are to be clearly understood.

There are other reasons, though, for looking away from perceptual factors in search of an explanation for children's phonological development. For one, there simply is no compelling evidence for perceptual theory. For another, there are observations which either militate against perceptual theory or encourage alternative speculation.

The recent work on infant's phoneme perception is relevant here. Apparently, it is possible for infants to discriminate between phonetic segments which differ only by voicing or place of articulation. In Moffitt's work (1969), four-month-old infants demonstrated discrimination between synthetic forms of /ba/ and /ga/ by way of cardiac deceleration. In the work by Eimas and others (1970), one-month-old infants discriminated between synthetically-generated /pa/ and /ba/ as evidenced by changes in sucking rate. That in the first month of life infants reveal discrimination between segments phonemic to adults seems to suggest either that the basis for such distinctions is present at birth or so incredibly simple as to be acquirable in the first 30 days in the crib.[4]

Another reason for looking beyond or away from phoneme perception as omnipotent in children's acquisition of phonology comes from data on children whose phonological systems are at variance with the adult community. True, previous work has often shown these children to perform less well on tests of phoneme discrimination than children whose sound systems are well formed. But our work has shown that while this may be so, the phonemic contexts in perception and production simply do not match. That is, children who misarticulate do get low scores on discrimination tests but they do not necessarily miss the same items in their perception as they do in production. We think these lower scores may be due to the recent observation (Locke and Goldstein,

1970) that misarticulating children simply do not attend to acoustic stimuli in an experimental setting and therefore, there is the possibility that previous findings are test-taking phenomena.

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Footnotes

[1] This research was conducted at the Children's Research Center, University of Illinois, and supported by Public Health Research Grant MH-07346 from the National Institute of Mental Health.

[2] Mastery by three-year-olds is not quite the same as acquisition schedule over a period of years, but is easier to rank, is more precise, and leads to essentially similar results.

[3] We also wanted to avoid any kind of data derived from adult perceptual behavior. Olmsted (1966) based his entire case for discriminability theory of children's learning of phonology on the perceptual confusions of adults reported in Miller and Nicely (1955). However, there now is evidence that children and adults do not even respond to the same acoustic cues in perceiving speech (Koenigsknecht and Rutherford, 1968).

[4] Although I do not hold the latter view, it should be noted that such rapid acquisition may be possible. It has been observed that infants from one to seven days of age do monitor their acoustic environment and adjust their vocal behavior on the basis of auditory feedback from their own voice (Cullen, Fargo, Chase, and Baker, 1968).

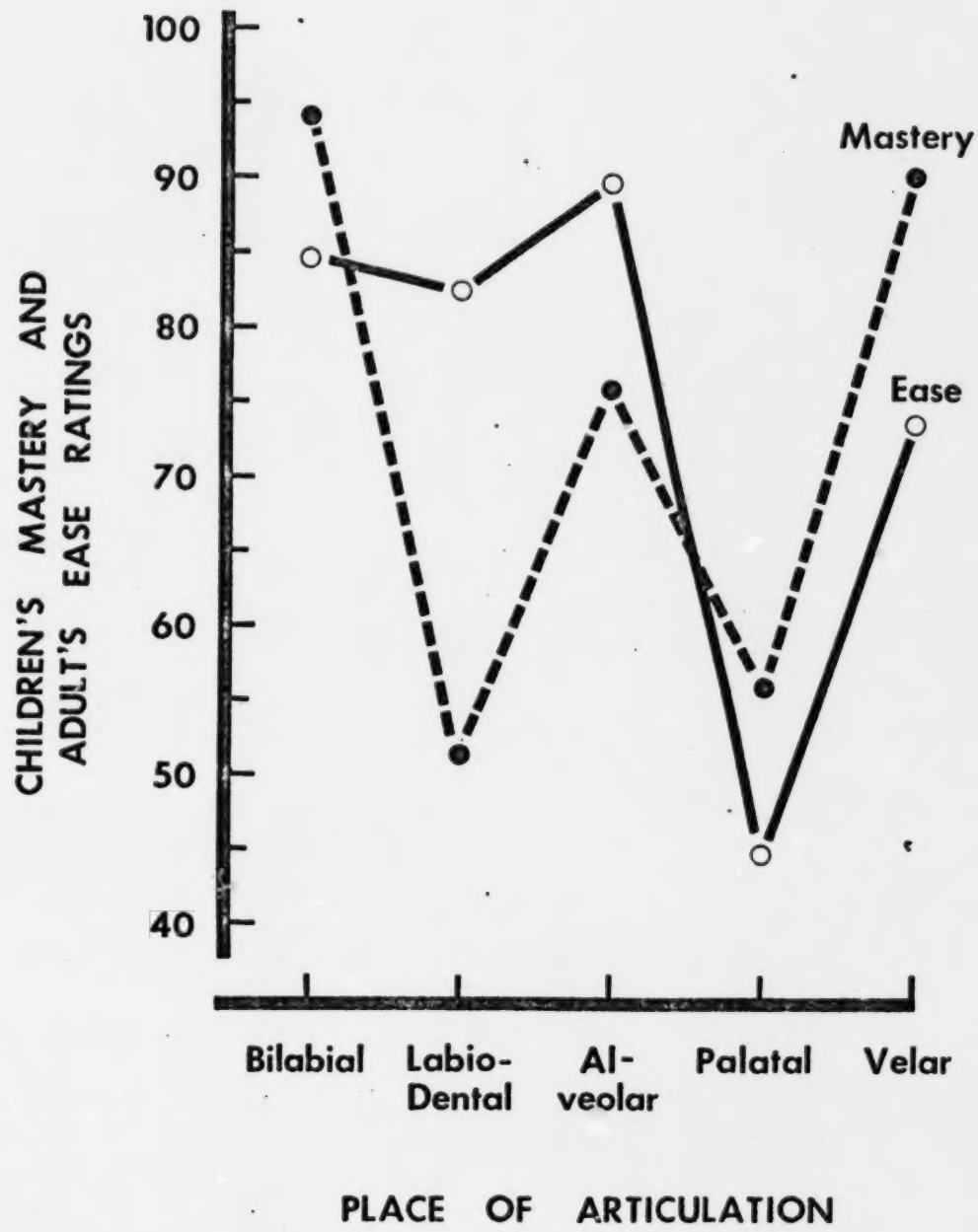

Figure 1. Children's degree of articulatory mastery (from Templin, 1957) and adult's ratings of muscular ease of producing phonemes, analyzed by place of articulation (100 percent = high degree of mastery, great ease).

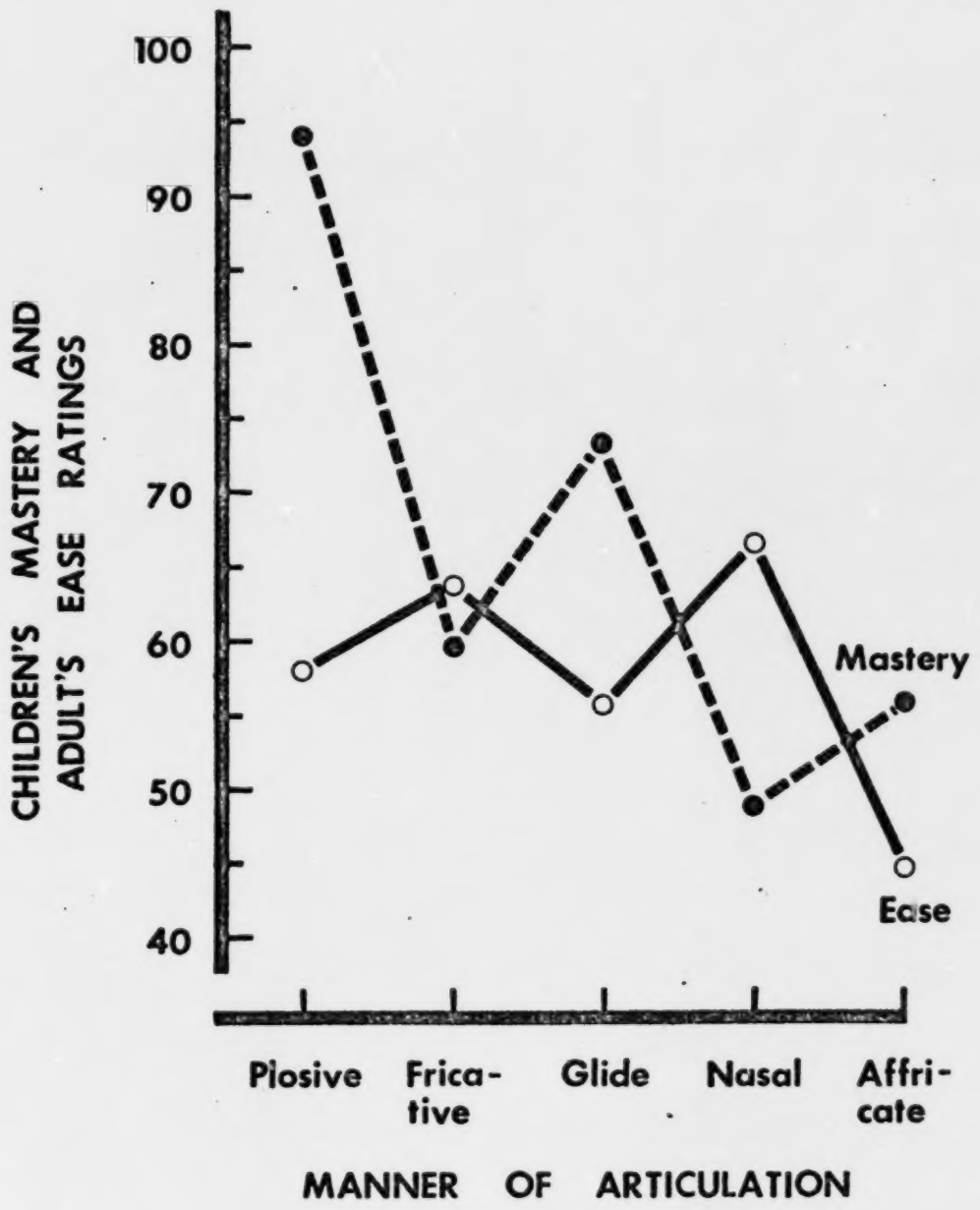

Figure 2. Children's degree of articulatory mastery (from Templin, 1957) and adult's ratings of muscular ease of producing phonemes, analyzed by manner of articulation (100 percent = high degree of mastery, great ease).

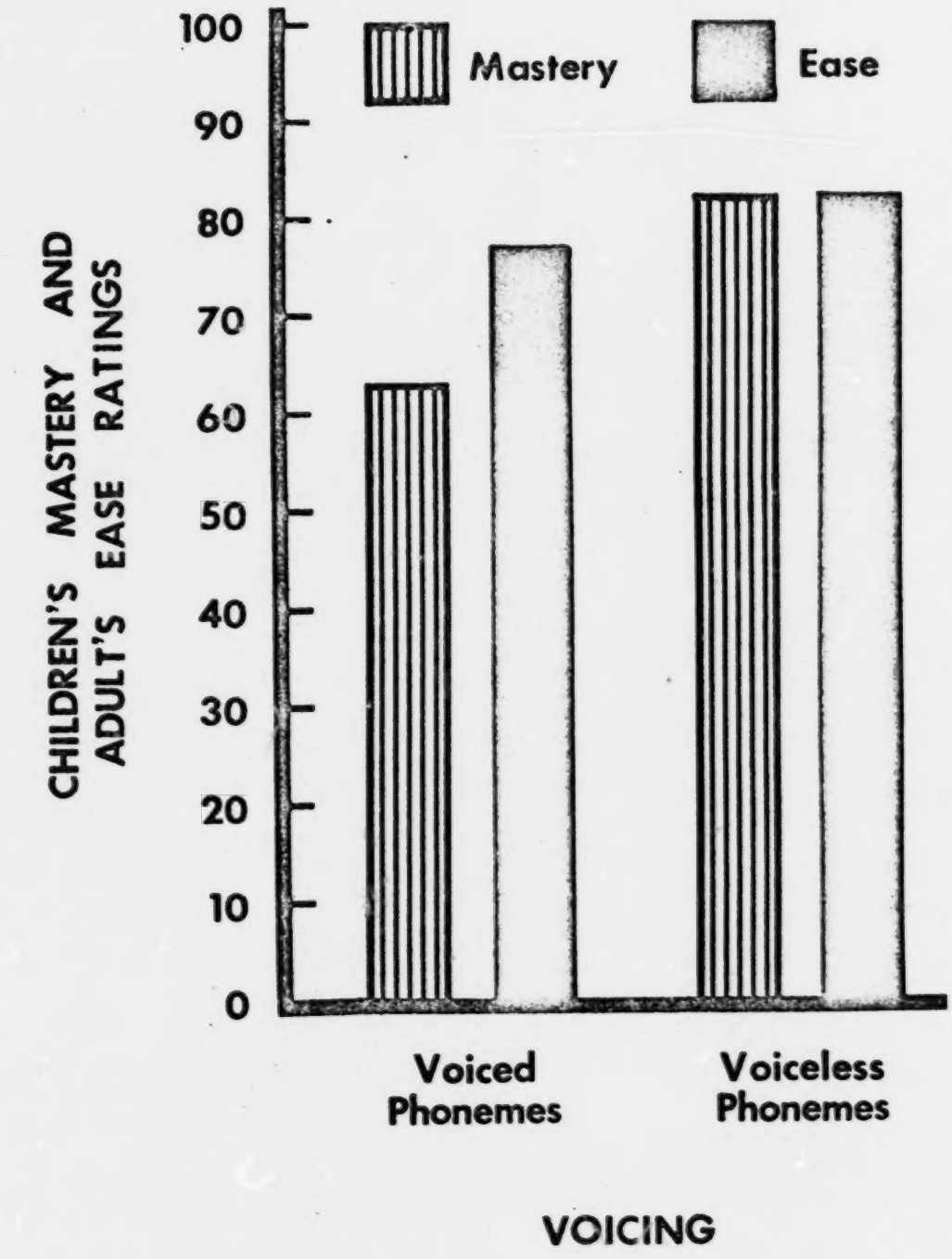

Figure 3. Children's degree of articulatory mastery (from Templin, 1957) and adult's ratings of muscular ease of producing phonemes, analyzed by voicing (100 percent = high degree of mastery, great ease).